(L) Teacher Resource. Marsbound! Rubric (1 of 3)

You will know the level to which your students have achieved the **Learning Outcomes**, and thus the **Instructional Objective(s)**, by using the suggested **Rubrics** below.

Instructional Objective 1: To design a technological solution (mission) by making tradeoffs within constraints

Related Standard(s) (will be replaced when new NRC Framework-based science standards are released):

National Science Education Standards (NSES)
(E) Science & Technology: Abilities of Technological Design
Identify appropriate problems for technological design. Design a solution or product; Evaluate completed technological designs or products; Communicate the process of technological design. (Grades 5-8: E1a)

National Science Education Standards (NSES)
(E) Science & Technology: Understandings about Science & Technology

Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. (Grades 5-8: E2a)

Science and technology are reciprocal. Science helps drive technology, as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and technique. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, and inquiry. (Grades 5-8: E2c)

Perfectly designed solutions do not exist. All technological solutions have tradeoffs, such as safety, cost, efficiency, and appearance. Engineers often build in back-up systems to provide safety. Risk is part of living in a highly technological world. Reducing risk often results in new technology. (Grades 5-8: E2d)

Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, or effects of weather and friction; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics. (Grades 5-8: E2e)

(Associated rubric next page.)

(L) Teacher Resource. Marbound! Rubric (2 of 3)

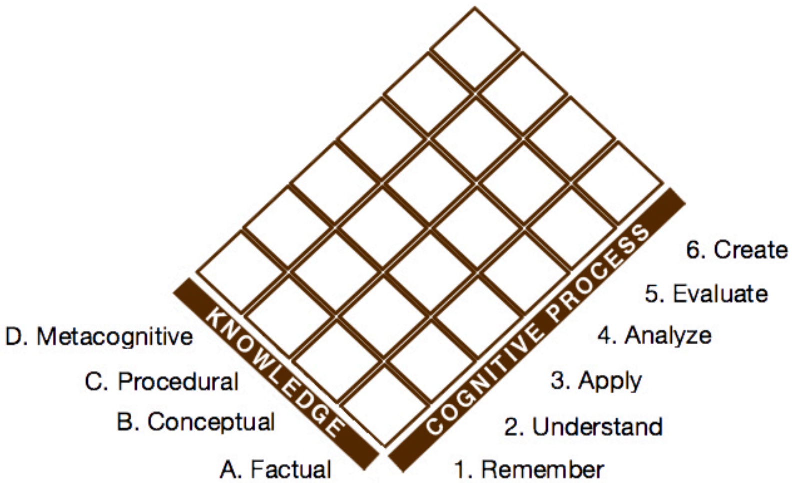
Learning Outcome	Expert	Proficient	Intermediate	Beginner
LO1a: to differentiate between the purposes of scientific inquiry and technological design	Student can articulate the difference and provide many examples.	Students can articulate the differences and provide examples.	Student can somewhat articulate the differences.	Student is uncertain of the distinction.
LO1b: to analyze requirements and constraints in a design task	Design takes into account complexity of balancing budget, mass, power and science return. Modifies design significantly using pre-established science goals during the simulation.	Design accounts for complexity of balance between budget, mass, power and science return. Modifies the design during the simulation.	Design takes into account the balance between budget, mass, and power and therefore modifies the design during the simulation.	Design tends to focus only on Spacecraft components that are of interest to the builder, and is over budget, mass, and or power.
LO1c to construct an appropriate science question (problem) requiring a technological design	Mars Exploration Program Goals are chosen because the student is able to identify and explain the strong connection between water and the need to answer the science question to learn more about those water processes.	Mars Exploration Program Goals are chosen because the student is able to explain the water processes involved and/or how they work.	Mars Exploration Program Goals are chosen because student is able to identify that there is a connection to water processes, but may not be clear on what the processes are or how they work.	Mars Exploration Program Goals are chosen because the student likes or prefers them. Responses are often limited to 1 or 2 words.
LO1d to generate an appropriate technological solution within constraints	Justifications are based on experiences in the simulation and are relevant to engineering constraints. Demonstrates complexity of these constraints.	Justifications are based on experiences in the simulation and selects examples that partially describe the complexity in engineering constraints.	Justifications are based on experiences in the simulation. Student identifies examples from the simulation.	Justifications are based on misconceptions or previous understanding/beliefs. Uses personal preferences for justification.
LO1e to explain the complex relationship between science and engineering design	Post-survey responses demonstrate the student has connected to the complexity of mission planning and recognizes their new understanding of mission planning.	Post-survey demonstrates the student has connected to the complexity of mission planning using a variety of examples and explanations.	Post-Survey responses indicate an understanding of the connection between engineering constraints and a good mission.	Post-Survey responses tend to focus on one engineering constraints or are very similar to Pre-Survey responses.

(L) Teacher Resource. Marsbound! Rubric (3 of 3)

21st Century Skills

Learning Outcome	Expert	Proficient	Intermediate	Beginner
Effectiveness of collaboration with team members and class.	Extremely Interested in collaborating in the simulation. Actively provides solutions to problems, listens to suggestions from others, attempts to refine them, monitors group progress, and attempts to ensure everyone has a contribution.	Extremely Interested in collaborating in the simulation. Actively provides suggestions and occasionally listens to suggestions from others. Refines suggestions from others.	Interested in collaborating in the simulation. Listens to suggestions from peers and attempts to use them. Occasionally provides suggestions in group discussion.	Interested in collaborating in the simulation.
Effectiveness in communication	Communicates ideas in a clearly organized and logical manner that is consistently maintained.	Communicates ideas in an organized manner that is consistently maintained.	Communications of ideas are organized, but not consistently maintained.	Communicates ideas as they come to mind.

(M) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (1 of 3)

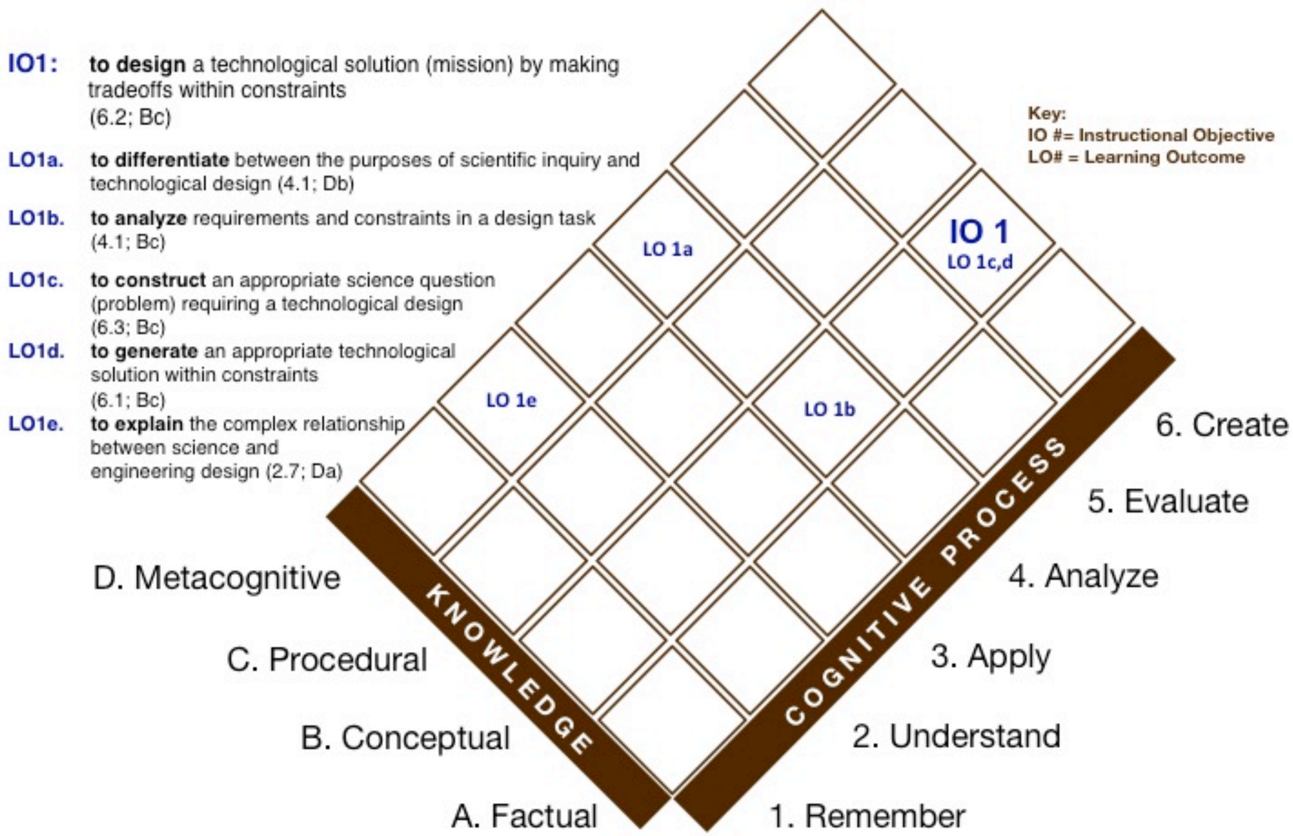


This lesson adapts Anderson and Krathwohl's (2001) taxonomy, which has two domains: Knowledge and Cognitive Process, each with types and subtypes (listed below). Verbs for objectives and outcomes in this lesson align with the suggested knowledge and cognitive process area and are mapped on the next page(s). Activity procedures and assessments are designed to support the target knowledge/cognitive process.

Knowledge	Cognitive Process
A. Factual **Aa:** Knowledge of Terminology **Ab:** Knowledge of Specific Details & Elements **B. Conceptual** **Ba:** Knowledge of classifications and categories **Bb:** Knowledge of principles and generalizations **Bc:** Knowledge of theories, models, and structures **C. Procedural** **Ca:** Knowledge of subject-specific skills and algorithms **Cb:** Knowledge of subject-specific techniques and methods **Cc:** Knowledge of criteria for determining when to use appropriate procedures **D. Metacognitive** **Da:** Strategic Knowledge **Db:** Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge **Dc:** Self-knowledge	**1. Remember** **1.1** Recognizing (Identifying) **1.2** Recalling (Retrieving) **2. Understand** **2.1** Interpreting (Clarifying, Paraphrasing, Representing, Translating) **2.2** Exemplifying (Illustrating, Instantiating) **2.3** Classifying (Categorizing, Subsuming) **2.4** Summarizing (Abstracting, Generalizing) **2.5** Inferring (Concluding, Extrapolating, Interpolating, Predicting) **2.6** Comparing (Contrasting, Mapping, Matching **2.7** Explaining (Constructing models) **3. Apply** **3.1** Executing (Carrying out) **3.2** Implementing (Using) **4. Analyze** **4.1** Differentiating (Discriminating, distinguishing, focusing, selecting) **4.2** Organizing (Finding coherence, integrating, outlining, parsing, structuring) **4.3** Attributing (Deconstructing) **5. Evaluate** **5.1** Checking (Coordinating, Detecting, Monitoring, Testing) **5.2** Critiquing (Judging) **6. Create** **6.1** Generating (Hypothesizing) **6.2** Planning (Designing) **6.3** Producing (Constructing)

(M) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (2 of 3)

The design of this activity leverages Anderson & Krathwohl's (2001) taxonomy as a framework. Pedagogically, it is important to ensure that objectives and outcomes are written to match the knowledge and cognitive process students are intended to acquire.



(M) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (3 of 3)

The design of this activity leverages Anderson & Krathwohl's (2001) taxonomy as a framework. Below are the knowledge and cognitive process types students are intended to acquire per the instructional objective(s) and learning outcomes written for this lesson. The specific, scaffolded 5E steps in this lesson (see 5.0 Procedures) and the formative assessments (worksheets in the Student Guide and rubrics in the Teacher Guide) are written to support those objective(s) and learning outcomes. Refer to (M, 1 of 3) for the full list of categories in the taxonomy from which the following were selected. The prior page (M, 2 of 3) provides a visual description of the placement of learning outcomes that enable the overall instructional objective(s) to be met.

At the end of the lesson, students will be able

IO1: to design solution w/model, inc. constraints

6.2: to design

Bc: knowledge of theories, models, and structures

To meet that instructional objective, students will demonstrate the abilities:

LO1a: to differentiate between inquiry and engineering design

4.1: to differentiate

Db: knowledge about cognitive tasks, inc. contextual and conditional

LO1b: to analyze requirements/constraints

4.1: to distinguish

Bc: knowledge of theories, models, and structures

LO1c: to construct an appropriate science question

6.3: to construct

Bc: knowledge of theories, models, and structures

LO1d: to generate solutions

6.1: to generate

Bc: knowledge of theories, models, and structures

LO1e: to explain sci/eng relationships

2.7: to explain

Da: strategic knowledge